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THE UTILIZATION OF THE WIND ENERGY

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The Utilization of the Wind Energy

Prof. Ing. Renzo Vezzani

Dear Sir:

At the XLVIII Convention in Turin it was not possible to /463* discuss the question of the utilization of the wind energy as thoroughly as the importance of the subject should deserve because of the lack of time.

One of the papers I presented at the convention had the title, "The Accumulation in Time and Space of Wind Energy in the Large Wind Electric Power Stations". It described briefly the present stage reached abroad in actual constructions and in designs in the field of large wind electric power stations. It pointed out the scarcity and the insufficiency of the constructions and the absolute impossibility of carrying out these plans in Italy. These plans are all based on wheels with large diameters (around 130 m) and on very high iron frameworks (around 250 m).

From this survey the conviction was derived that, in spite of the efforts made and the advanced research carried out until now, the study of the question has clearly demonstrated a lack of ability to perform although it has not been admitted, but in my opinion there is no other interpretation for the fact that these colossal projects have not been carried out.

This idea is contrary to another more profound belief, which is that up to now one may have been struggling with the wrong approach as is confirmed by the first, more exact impressions. Since the wind energy is dispersed in space, it is necessary to use immense surfaces to capture it. These

* Numbers in the margin indicate pagination in the foreign text.

large surfaces are vulnerable and may be damaged beyond repair by sudden storms.

In order to utilize the energy in the wind, like the energy in the tides, in the waves and elsewhere in nature, it should first be accumulated in a reduced space. This is similar to the solar energy, which is concentrated by burning glasses according to Archimedes' old idea now picked up by the Russians with the creation in Central Siberia of a small plant with a steam boiler heated by parabolic mirrors with a surface of 80 m^2 . The wind energy can easily be concentrated in space * by enclosing the aeroengine in a round enclosure according to the well-known principle of the conversion of kinetic energy into potential energy when the flow expands. For this one uses a Venturi tube. When it is exposed freely to the air in the direction of the wind, the narrowed-down section gives rise to an increased velocity in the air current of from two to three times the velocity with which the wind strikes the front section, depending upon whether the ratio between the two cross-sections is, respectively, one to three or one to five.

The principle of the conservation of energy in the two cross-sections confirms the coefficient obtained from experience for the increase in velocity except for a correction factor, which is very close to unity depending upon the variations in the density of the air caused by small differences in pressure in the two sections and disregarding the small losses caused by air friction along the tube. These sources of error, which are very small for average wind velocities, have a favorable effect in reducing the velocity of the air current in the tube when the wind velocity exceeds a certain maximum value determined by the security of the aeroengine.

* Italian patent: Vezzani Renzo, "Device for multiplying the power of aeroengines in large aeroelectric power stations".

Since the power of the aeroengine is proportional to the cube of the wind velocity, it can be deduced from this that by using the Venturi tube it is possible to increase the power produced by an aeroengine exposed to the open air by a factor of 8 or 27, respectively. One thus obtains a considerable advantage as compared to the method of mounting it on a high framework, which can multiply this power by a maximum of four.

The other problem of accumulating the wind energy in order to overcome periods with no wind or weak wind is also resolved automatically by enclosing the aeroengine in a tubular structure, since it will always be possible in this case to influence the depression which forms in the narrowed-down section of the Venturi tube artificially, either by injecting at the periphery compressed air stored up in periods of strong winds or by increasing these depressions with exhaust machines or other means. With the first system one simultaneously succeeds in: acting on the ends of the vanes and thus with the maximum torque; restricting the flow cross-section and increasing the velocity of air flow with whirling motions produced by the turbulence at the periphery; and increasing the depression in the narrowed-down section both by increasing the velocity of the air current and by condensing the water vapors contained in the air and thus cancelling out the corresponding vapor pressure. In the second system the velocity of the air current in the narrowed-down section is directly related to the square root of the depression at that place in accordance with a well-known property of the Venturi tube. From this it is thus deduced that, especially in the first system, it will always be possible to utilize the excess wind energy by accumulating it in time, not the total amount as they now do in hydroelectric plants, but only that part of the energy which is sufficient to place in motion the air masses always available on the outside.

In this process one follows completely the laws of nature for the circulation of air, regulated, as is well known, by the distribution of barometric pressure so that a difference of a few millibars distributed over some hundreds of kilometers is sufficient to produce variations in the wind velocity of several degrees on the Beaufort scale.

In contrast to this clumsy imitation of nature, which will guarantee the natural development of all the subsequent operations, we have instead the undeniable subversion of the laws of nature perpetrated with the storage of large amounts of water at higher and higher altitudes above their natural bed. Inevitable consequences of such a procedure are: the continuous fear the population below lives in because of the danger that the dam may collapse even partially (in the calculation of, for instance, the wave from the overflow which would take place if the dam at Cancano in the upper Adda valley would break, professor De Marchi had recently determined the peak rate of flow which would be discharged in two hours on Tirano at $1,750 \text{ m}^3/\text{sec}$); the deprivation for the population in vast, very close areas of the most precious vital elements and the profound changes in the biological laws which control the fertility of the soil on a very large scale that is felt in immense regions far below the reservoirs, which also came out in discussions held at the convention concerning the control of the irrigation waters from rivers with hydroelectric plants in high valleys; the rapid filling-up of reservoirs due to massive slides against which there is practically no defense (in connection with this we report the case which occurred in the USA of the dam for the lagoon on the Colorado, 3.90 m high, 1,453 m long; it cost \$1,921,000 in 1909, and in less than one year it caused the basin which was created by it to fill up with dirt); the expensive maintenance made necessary by water losses caused by filtration through the dams; the struggle against the formation of ice in high mountain reservoirs; the water losses through evaporation in hot climates, etc.

In comparison with all this, in the large aeroelectric power plants using the Venturi tube device, the only danger is that of storms, and this danger can be readily eliminated by closing the narrowed-down section by means of, for instance, two semi-circular iron diaphragms, one being lowered from above and the other being raised from below. Even the construction of such plants has been made very simple both in terms of the use of labor, which could be at least 60% non-specialized since the lower half of the tube should be excavated in the terrain with labor, which might contribute to alleviate unemployment, and also in terms of requirement for raw materials necessary for building construction, such as cement and iron, which could be reduced to a minimum by trying to carry out only the upper part of the tube in reinforced concrete. In contrast to these very modest and favorable expectations are the enormous requirements for hydroelectric plants anticipated by engineer Ferrerio, president of the Association of the Electrical Societies, for fulfilling the program to increase the electric production by 2 billion kWh yearly. His figures were 800,000 tons of cement and 120,000 tons of iron yearly or one third and one tenth of the present national production, respectively.

The value of the obtainable power in these aeroelectric power plants could, of course, be considered to be of the same order of magnitude as the large hydro- and thermoelectric power plants.

In fact, with wind engines of 12 m diameter and Venturi tubes with a front section of 60 m diameter, the installed power for natural wind of a speed of 15 m/sec may be calculated at approximately 6,250 kW. This is with a complex of 8 such tubes enclosing the wind engine and sunk into a bank in the ground constructed with a barricade from a mountain embankment one could obtain an installed power of 50,000 kW.

A connected, compressed air tank with a capacity of $1,200,000 \text{ m}^3$, which, when reduced to $6,000 \text{ m}^3$ with a pressure of 200 atmospheres, would occupy the space of the piezometric well of a diameter of 16 m and a depth of 40 m in the hydroelectric plant a delegate has referred to. It could replace the seasonal reservoir by storing enough energy to overcome periods with no or with weak winds in the summer and in the spring *.

The cost of such a hydroelectric power plant with energy storage would amount to approximately 40,000 lire per kW and for a kWh it would be 10 lire including the amortization and the inactive interest on the capital.

It now remains to mention the necessity for statistics on the wind resources to be compared with statistics on water resources so as to have a directive in impending decisions to be made concerning whether or not it is advantageous to substitute or integrate the anticipated large hydro- or thermoelectric plants with aéroelectric power stations of the same power centralized or, more conveniently, divided on the basis of local demands both from industry as well as from agriculture according to a plan for rural electrification and for providing electricity for the production of the most essential construction materials to be developed simultaneously.

In order to be able to develop the two statistics on mutually parallel bases so as to be able to compare the results, it is necessary to be able to trace, for every region, the isotachs of average duration in the year, derived from the curves for the duration of the wind velocity, which in turn are traced in the

* In isolated direct current power plants, for water one could substitute hydrogen dissociated electrolytically from the water. It has a high calorific value, which can be utilized in various ways.

normal way on the basis of a study of the wind speed in each location based on the conversion of differences in pressure and direction of isobars into wind velocities and directions according to well-known formulas and tables now in general use in meteorology. This was already indicated in the other communication I presented at the conference: "New Directives and Purpose of a Statistic of Wind Resources". These meteorological elements can be derived daily and even several times a day from maps of isobars for forecasting the weather. These are gradually being compiled by the weather bureau and are kept on file for a period of at least 10 years except for wartime interruption.

From the above-mentioned maps of isotachs of average duration in the year one will then draw in roughly the accumulation of lines of force from the wind energy along the large directors of the valleys or across the saddles of the crests or the mountain crests to the junctions of the high valleys on the opposite slopes or in proximity to the glaciers or at the drawdown at the outlet in sea basins of air currents from the hinterland, so that the only thing remaining is the difficulty of the choice in separating it with the above-mentioned Venturi tube obstructions so as to be able to also satisfy the other requirements of the power plants, such as the proximity to electric transmission lines, the cost of the work, the proximity to energy consumption centers, the possibility of creating new industries in the vicinity, etc.

Since the problem of utilizing the wind has thus come to maturity, both from an aerodynamic as well as an electrical point of view (the question of feeding three-phase energy at constant frequency and voltage into the network for plants that have been tied together or the question of producing direct-current energy with isolated plants has also been solved completely and in various ways as has been demonstrated in other communications presented at the conference), it would therefore be necessary to

proceed immediately to the construction of a pilot plant of modest dimensions to obtain the necessary experience and controls and then proceed to carry out completely on a vast scale a program for utilizing the wind. This program would go step in step with the always growing energy requirements for industry and agriculture. It would follow untested paths, such as rural electrification and using electrical energy for producing the most essential materials for building constructions, such as cement, bricks, lime, etc.

While I am thanking you, the editor, cordially for the hospitality offered in your great journal, I would appreciate it very much if you could also allow the discussion on this important subject to continue in this way.

Prof. Ing. Renzo Vezzani

Rome, 2 October, 1947

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